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OCCURRENCE OF THE PACIFIC LAMPREY,  
*ENTOSPHEMUS TRIDENTATUS*, OFF BAJA CALIFORNIA  
AND IN STREAMS OF SOUTHERN CALIFORNIA;  
WITH REMARKS ON ITS NOMENCLATURE

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ABSTRACT

A specimen of the anadromous Pacific lamprey, *Entosphenus tridentatus*, taken in a huge pelagic trawl in the cool, up-welled ocean water off Baja California, Mexico, represents a marked southward extension of the range of the genus and species, and of the family, in the eastern Pacific Ocean. The source from which it strayed is uncertain. Until their very recent local probable extirpation, this species and a probably unnamed nonparasitic species of *Lampetra* occurred in streams of the Los Angeles Basin. *E. tridentatus* still persists in streams of the Ventura Basin, also in southern California. Records of *E. tridentatus* at sea are relatively few, and none have pertained to the coast south of Monterey Bay, California. A racial analysis of the species is needed. The separation of a northern and a southern subspecies seems invalid. Proper designation of species and author names is *Entosphenus tridentatus* (Gairdner in Richardson). The separation of *Entosphenus* from *Lampetra* appears justified, and it seems advisable to recognize as genera the three taxa proposed by Creaser and Hubbs as subgenera of *Entosphenus*, namely *Tetrapleurodon* and *Lethenteron*, as well as *Entosphenus* proper, which includes an unnamed nonparasitic derivative.

This paper is an element in a study of the fishes of the "California Peninsula," which contains a distinctive fauna extending from near Point Conception in California southward for several hundred miles, with a sharp transition to the tropical fauna in the Cape region of Baja California, México. The program has been supported by the National Science Foundation (currently by Grant GB-1321).

Thanks are due H. C. Perkins, then of the U. S. Bureau of Commercial Fisheries laboratory at La Jolla, who preserved the range-extending specimen from off Baja California and brought it to me for study, and to the Exploratory Fishing staff of the same bureau, at Seattle, for supplementary data on the trawl and the gear. Thomas T. Harriss of Whittier College supplied information regarding lampreys collected prior to 1945 in San Gabriel River, California. James A. St. Amant and staff and Robert R. Bell of the California Division of Fish and Game, Keith W. Radford, formerly of Scripps Institution, and Robert Rush Miller, of The University of Michigan, have been among those who have helped me in obtaining material and data on lampreys in the streams of southern California. W. I. Follett, of the California Academy of Sciences, and Vadim D. Vladykov, of the University of Ottawa, have made helpful suggestions.

All specimens studied, with the exception of one in The University of Michigan Museum of Zoology (UMMZ), are deposited in the Marine Vertebrates collection of Scripps Institution of Oceanography (SIO).

DISCOVERY OFF BAJA CALIFORNIA AND FAUNAL IMPLICATIONS

The capture off western Baja California, Mexico, of a specimen of the anadromous Pacific lamprey, *Entosphenus tridentatus* (Gairdner in Richardson) represents a range extension, far to the southward in the Pacific Ocean, for the family Petromyzonidae, as well for

<sup>1</sup>Contribution from the Scripps Institution of Oceanography, University of California, San Diego.

the genus and species. This discovery parallels recently reported range extensions to western Baja California of certain other West Coast anadromous fishes: salmon (Hubbs, 1946), sturgeons (Hubbs and Márquez Millán, MS) and shad (Claussen, 1959). Occurrence of northern fishes and other animals in the area of cold upwelling along the northwestern coast of Baja California is to be expected (Hubbs, 1960). A recent, rather startling range extension of this nature (Hubbs and Wilimovsky, 1964) is that of a Greenland halibut, *Reinhardtius hippoglossoides* (Reinhardt).

Lampreys (Petromyzonidae) have long been known from farther south in North America, but, south of the United States, only as a relict type landlocked in the highly distinctive fauna of the Río Lerma basin at the southern end of the Mexican Plateau. This type has generally been known as *Entosphenus spadiceus* (Bean), but Alvarez del Villar (1966) has recently described a second species from the same basin, *geminis*, the nonparasitic counterpart of *spadiceus*, and has referred the two species to a distinct genus, *Tetrapleurodon* (see also the section below on Nomenclature).

The lamprey from off Baja California, a juvenile male 170 mm in total length (SIO 67-22-4), was captured in a John N. Cobb pelagic trawl that was catching hake at 28° 58.6' N., 115° 25.6' W., 29.5 nautical miles southwestwardly from Punta Canoas (the nearest place on the mainland) and 37.3 miles northerly from the north end of Isla Cedros. At the indicated point of capture Hydrographic Office Chart 1193 shows depth of water as 460 fathoms (841 m). Maximum depth of tow was 388 m, where temperature registered 7.2° C.; surface temperature was 15.6° C. The haul was made by the exploratory-fishing vessel John N. Cobb, of the U. S. Bureau of Commercial Fisheries, at Station 34 on Cruise 64, at 1400-1530 hrs. P.S.T., on March 9, 1964.

The capture of this specimen seems attributable to the remarkable capacity of the huge John N. Cobb pelagic trawl (McNeely, 1963) with "a measured opening of 80 feet horizontally and 90 feet vertically (7,200 sq. ft.)." This net engulfs fish too large or too active to be trawled ordinarily, even in the highly efficient 10-foot Isaacs-Kidd midwater trawl. However, Percy (1964: 87) reported capture of this lamprey by midwater trawl off Oregon.

The region from which this stray lamprey ranged to the far-southern station cannot be pinpointed, either by the circumstances of its capture or by its inherent characters (see below). It is rather plausible to assume that it hitch-hiked a ride on a hake, *Merluccius productus* (Ayres). The same haul took 158 hake weighing nearly 200 kg, along with a few juvenile jack mackerel, *Trachurus symmetricus* (Ayres), and several small species of bathypelagic fish, none of which was a likely host. Probably, this lamprey had spent its early life no farther south than one of the streams tributary to Monterey Bay, central California, the southernmost streams in which any massive spawning of the species has been recorded (Snyder, 1913: 56).

#### OCURRENCE IN STREAMS OF SOUTHERN CALIFORNIA

*Entosphenus tridentatus* has long been known to migrate occasionally into the dwindling streams of southern California. Jordan and Evermann (1896: 12) indicated its range as extending to Santa Ana River at Riverside. Culver and Hubbs (1917: 83) reported it as anadromous in the same river, and mentioned taking ammocetes in Los Angeles River, which then flowed at the surface (however, these larvae may have been brook lampreys of the genus *Lampetra*, which may still inhabit the streams of the Los Angeles Basin). Fowler (1923: 286) listed *E. tridentatus* from "Los Angeles," without indicating the exact location, habitat, or life-history stage (if the record was based on an ammocete, it may have been referable to *Lampetra*; efforts to locate the material have failed). In their review of records of freshwater fishes in California, Evermann and Clark (1931: 47) listed, for southern California, only the report by Jordan and Evermann.

The most recent capture known to me of an adult lamprey in California south of Ventura County was reported by Ewy (1945):

An adult lamprey measuring 514 mm. in length was found in an irrigation pipe-line by W. R. Newsom after it had passed through three miles of 30 inch pipe, along with water from Cate Dam, before it came through the head valve.

Although I was unable to check the identification of this specimen, now reportedly lost, its size seems to assure identification as *Entosphenus tridentatus*. Ewy further noted the collection in San Gabriel River during 1943-44 of 3 ammocetes (not yet identified). Several ammocetes from San Gabriel and Santa Ana rivers collected in the 1950's and earlier appear to represent an undescribed nonparasitic species of *Lampetra* with fewer than 65 trunk myomeres.

It seems probable that lampreys no longer persist in the dwindling Los Angeles, San Gabriel, and Santa Ana rivers (the somewhat interconnected "Santa Ana system of streams" of Culver and Hubbs, 1917), within which only pockets remain of the native fish fauna that these authors listed. An intensive effort by Keith W. Radford and party from Scripps Institution to collect any indigenous fishes in these streams, on the Los Angeles Plain, in May and June, 1962, yielded introduced fishes only. Here, as over much of the West, depletion of the waters and the introduction of more aggressive Eastern fishes have rapidly brought the native fish fauna to or beyond the brink. I have found no evidence of any lamprey occurrence at anytime in coastal streams south of the Los Angeles Plain.

*Entosphenus tridentatus* appears to have fared less badly in the streams of the Ventura Basin, through which the Ventura and Santa Clara "rivers" and several creeks flow, or once flowed, into the sea. Through the cooperation of James A. St. Amant, of the Chino Fisheries Base of the state Division of Fish and Game, Keith W. Radford secured three recently collected specimens from this basin in June, 1962. All came from Sespe Creek, a tributary of Santa Clara River, about 3 miles north of Fillmore (which is near the stream junction), in Ventura County. One, an advanced ammocete 124 mm long (SIO 62-273-4) had been taken by Don Haase on or about June 1, 1962, in mud at the base of a filter screen in an irrigation-diversion channel. Another, a spent male in early stage of necrosis (with tips of disc-tooth cusps worn through, and skin slightly damaged), 455 mm long (SIO 62-272-4), had been saved by Don Goodenough on April 29, 1962, from 1 mile below check dam. The third specimen, a spent male more advanced in necrosis (with disc-tooth cusps obliterated, posterior marginals and all but central posterior circumorals shed, laterals too eroded to count cusps, and skin rather massively damaged), 502 mm long (SIO 62-274-4), had been secured by Don Haase on or about May 25, 1962, in the creek near check dam.

The dates on which the males were taken suggest that this lamprey spawns in Sespe Creek in late March or in April, and that it migrates into and up Santa Clara River during brief periods in the winter, when the depleted surface waters reach the sea.

According to Sidney B. Peyton (personal communication to W. I. Follett, April 17, 1964), lampreys as long as two feet occurred many years ago in Sespe Creek upstream to about four miles above Henley's Camp (which is about four miles in a northerly direction from Fillmore). An adult specimen (UMMZ 133774) was seined by R. G. Miller and W. I. Follett on May 4, 1941 in the lagoon at the mouth of Santa Ynez River, Santa Barbara County.

#### OTHER RECORDS OF THE PACIFIC LAMPREY AT SEA

Considering the vast hordes of *Entosphenus tridentatus* that at various sizes migrate up many coastal streams of the North Pacific to spawn, there are relatively few records from the sea, and I have found none for south of Monterey Bay, the southernmost region of known major stream runs. Following are the reports I have noted, in order from south to north:

*Monterey Bay, California*: Jordan and Gilbert, 1881a: 30; 1881b: 458; Gilbert, 1895: 395; Rutter, 1908: 119.

*San Francisco Bay, California*: Girard, 1858: 378-379.

*San Pablo Bay, California*: Evermann and Latimer, 1910: 132.

*Off Oregon (midwater-trawled)*: Percy, 1964: 87.

*Puget Sound*: Starks, 1911: 206.

Off Barkley Sound 24 miles, British Columbia: Clemens and Wilby, 1946: 47; 1961: 68-69.

Vicinity of Coal Harbour, British Columbia (4 in stomach of a sperm whale; unidentified, but presumably *E. tridentatus*): Pike, 1950: 27-28.

Strait of Georgia, British Columbia (preying on salmon): Fraser, 1921: 50.

Off Queen Charlotte Islands, British Columbia (large specimen from stomach of sperm whale): Pike, 1951: 279.

Vicinity of Skeena River mouth, British Columbia (in stomach of harbor seal): Fisher, 1952: 39.

Aleutian area (5 taken on high seas): Larkins, 1964: 288-289.

Bering Sea (5 from stomach of a fur seal): Lucas, 1899: 67-68; Jordan and Gilbert, 1899: 434.

Bering Sea, Soviet portion (in stomach of sperm whales): Svetovidova, 1948.

Further evidence on the oceanic activities of *Entosphenus tridentatus* off British Columbia has been provided by scars on various fishes and whales showing the imprint of the diagnostic dentition of this lamprey (Pike, 1951; 1953). Nemoto (1955) has also dealt with lamprey scars on whales in the northwestern Pacific. He attributed marks to *E. tridentatus*, and one of his figures does indeed seem to exhibit the characteristic dentition of this species. Trophic relations are complicated by the circumstance that the lamprey feeds on the blood of the sperm whale, which in turn eats the lamprey!

#### CHARACTERS OF THE BAJA CALIFORNIA AND SOUTHERN CALIFORNIA SPECIMENS

Characters of the Baja California juvenile, of the two spent adults and the one ammocete from Sespe Creek, California, and of the one maturing male from Santa Ynez River, were determined, in the hope that the data (Table 1) will prove useful when *Entosphenus tridentatus* is subjected to the urgently needed racial analyses. It is already evident that this species, like salmon and some other anadromous fishes, comprises a multitude of races, the members of which differ sharply in body size and to some extent in meristic and morphometric features. Methods of counting and measuring and the tooth nomenclature follow those promulgated by Hubbs and Trautman (1937: 27-40).

The juvenile from off Baja California differs markedly from the three adult specimens herein reported in the shorter tail, and smaller anterior parts (of head and branchial regions), except for the much larger eye, which is a holdover from the macrophthalmia stage. Because the anterior and posterior parts are smaller in the juvenile, the trunk must be relatively longer. Apparently the abdominal region grows with negative allometry, in contrast with the positive allometry of this region, seemingly related to fecundity, in many fishes, including the dwarf pelagic shark, *Euprotomicrus bispinatus* (Hubbs, Iwai, and Matsubara, 1967). Perhaps the relatively large abdomen of the juvenile lampreys represents an evolutionary response to the advantages of rapid growth due to occasional gorging with blood. The dorsal fins of the sea-caught juvenile are lower and less nearly contiguous, as expected. Most or all of these morphometric differences probably reflect ontogenetic change.

The incomplete tooth counts in the senile males prevent a full comparison with the ocean-taken juvenile. The cusps on the lingual laminae had remained sharp, presumably because the laminae are not rubbed against stones in the breeding activities.

The dentition of the sea-caught juvenile and the Santa Ynez River maturing male furnished complete tooth and cusp counts. In an unpublished variational analysis of dentition in the species I have found sharp racial difference in tooth and especially in cusp counts.

<sup>1</sup>Methods of counting and measuring and nomenclature of teeth follow specifications of Hubbs and Trautman (1937: 27-43).

<sup>2</sup>Outermost teeth.

<sup>3</sup>Median cusp bifid.

<sup>4</sup>Including the 3 lingual laminae.

<sup>5</sup>Outermost on left side with small cusp at inner base, outermost on right side with median cusp slightly bicuspid at extreme tip.

TABLE 1  
 Counts and measurements of specimens of *Entosphenus tridentatus*  
 from southern part of its range<sup>1</sup>

Location	Sespe Creek, California				Santa Ynez R.
	Off Baja Calif.	SIO 66-272.4	SIO 66-274.4	SIO 66-273.4	
Catalog number .....	SIO 67-22.4	SIO 66-272.4	SIO 66-274.4	SIO 66-273.4	UMMZ 133774
Stage .....	Young adult male	Early necrotic male	Late necrotic male	Ammocete	Maturing male
Weight, g (preserved) .....	7.5	220	215	2.3	414
Total length, mm.....	170	455	502	124	575
Proportions (per mil):					
Tail length .....	285	308	299	315	327
Body depth .....	80	98	63	60	81
Eye length .....	30.0	21.2	21.7	—	13.2
Snout length .....	79	93	83	—	79
Disc length .....	59	70	62	—	50
Over gill-openings .....	109	134	129	148	111
Height first dorsal:					
With fleshy base .....	26	44	44	6	26
Without fleshy base.....	22	33	31	6	21
Height second dorsal:					
With fleshy base .....	38	70	57	10	35
Without fleshy base.....	34	59	51	10	45
Length first dorsal.....	152	154	165	148	158
Length second dorsal .....	208	275	261	—	276
Width supraoral (base).....	21.2	23.3	23.9	—	19.3
Width infraoral (base).....	30.0	28.4	28.3	—	23.0
Counts:					
Trunk myomeres .....	68	69	68	70	60
Supraoral cusps .....	3	3	3	—	3
Infraoral cusps .....	5	5	5	—	5
Cusps on laterals (each side)	2-3-3-2	2-3-3-2	—	—	2-3-3-2
Anterior circumorals .....	5	5	—	—	5
Posterior circumorals .....	19	18	—	—	17
Bicuspid posterior circumorals <sup>2</sup> .....					
.....	1 + 1	1 + 0?	—	—	1 + 1 <sup>5</sup>
Total circumoral teeth.....	32	31	—	—	30
Total circumoral cusps .....	46	44	—	—	44
Outer disc teeth (all anterior)	8	—	—	—	8
Cusps on transverse lamina....	8+2 <sup>3</sup> +7	9+1+9	9+1+9	—	8+1+8
Cusps on longitudinal laminae	25—23	—	—	—	26—23
Marginals .....	53	58	—	—	54
Total teeth <sup>4</sup> .....	98	—	—	—	97
Total cusps <sup>4</sup> .....	180	—	—	—	180

## NOMENCLATURE CONSIDERATIONS

The trunk myomere counts of 68 to 70 (Table 1) in the 4 southernmost specimens herein treated fall within the range of 68-74 ascribed by Creaser and Hubbs (1922: 6) to a northern, nominate subspecies (*E. t. tridentatus*) and outside the range of 57 to 67 ascribed by them to a southern subspecies, which they called *E. t. ciliatus* (Ayres), with an indicated geographical range from southern Oregon to southern California. But later I (1925: 592) found a range of 67 to 76, usually 70 to 74, in a series from Coyote Creek in central California. The low count of myomeres ascribed to a southern subspecies in 1922 now appears to be attributable in part to the inclusion of counts on ammocetes from southern regions that were wrongly referred to *Entosphenus tridentatus*, whereas they actually represent a few-segmented, as yet apparently unnamed, nonparasitic species of *Lampetra* that ranges (or until the last few years did range) southward into southern California. The low values that now seem erroneously to have been held characteristics of a southern form of *E. tridentatus* may also have resulted from miscounts of the myomeres in poorly preserved specimens, in which the number of muscle bands are extremely difficult to enumerate by counting the superficial folds. Reliable counts on the two somewhat necrotic males from Sespe Creek and the maturing adult from Santa Ynez River could not be obtained until the skin had been cut and reflexed far enough to expose the lateral muscles.

It will be found, I believe, that some races within the species do differ in the average number of muscle bands on the trunk, as some species of *Ichthyomyzon* do (Hubbs and Trautman, 1937: 28-29), but, as of now, there is no valid ground for separating a northern and a southern subspecies of *E. tridentatus*. After this prediction was made, an adult from Santa Ynez River (although located between Coyote Creek and Sespe Creek, wherein high counts seem to prevail) was found to have only 60 trunk myomeres, seemingly outside the range for the other stocks.

The species name *tridentatus* is commonly attributed to Richardson (1836: 293-294), but should, I agree with W. I. Follett (personal communication), be assigned to Gairdner. Richardson listed "*Petromyzon tridentatus*. GAIRDNER, *in lit.*" in the synonymy of "*PETROMYZON TRIDENTATUS*. (Gairdner.)." He stated that "Dr. Gairdner gave it the name of *tridentatus*, from the upper side of the maxillary ring being armed with three conspicuous and contiguous teeth, of which the middle one is the smallest" [a main diagnostic feature of the species]; and directly quoted Gairdner's description of the color. These circumstances seem to fulfill adequately the stipulation of Article 50 of the International Code of Zoological Nomenclature that a person other than the author of the publication was "alone responsible both for the name and the conditions that make it available." Consequently, and in accordance with a not-too-felicitous provision in the International Code, the species name, when given with the author, should read *Entosphenus tridentatus* (Gairdner in Richardson).

In his revision of the lampreys of the Northern Hemisphere Berg (1931) restricted *Entosphenus* to *E. tridentatus* and referred to *Lampetra* other species having the circumoral row of teeth complete (with a posterior commissure joining the last pair of laterals). Bailey, et al. (1960: 6) carried the action farther by completely synonymizing *Entosphenus* with *Lampetra*. Berg's action was apparently taken on the assumed indication that the criterion of presence or absence of the posterior circumorals is unstable, but some of the very specimens figured by Berg to emphasize this point proved, after having been sent to me at The University of Michigan, to be incompletely transformed individuals in which the posterior circumorals had not yet erupted through the gum (but were visible on close inspection). The presence or absence of these teeth seems to provide a valid basis for generic separation, and it further seems advisable to recognize as genera the three taxa proposed as subgenera of *Entosphenus* by Creaser and Hubbs (1922: 6), namely (1) *Tetrapleurodon*, already so treated by Alvarez (1966), (2) *Lethenteron*, and (3) *Entosphenus* proper, comprising *E. tridentatus* (perhaps a species as well as racial complex) and its as yet unnamed nonparasitic geminate, of the Klamath and Sacramento river systems on either side of the Oregon-California line. The



separation of these three phyletic lines seems to have been fundamental and of long standing, appropriately to be indicated by generic recognition.

### SUMARIO

Un ejemplar de pez anádromo, la lamprea del Pacífico *Entosphenus tridentatus*, se recogió en una abundante pesca pelágica con trawl, frente a Baja California, México; en aguas oceánicas frías, de afloramiento. Este ejemplar indica una definida extensión meridional de la distribución en el Pacífico oriental, del género, la especie y también de la correspondiente familia. No es posible determinar con certeza la población original de donde procedería este ejemplar. Esta especie y una especie de *Lampetra* libre, no parásita (probablemente sin describir todavía) se encontraban en los riachuelos de la cuenca de Los Angeles, hasta que en fecha reciente han sido probablemente eliminados de esa región. Sin embargo, *E. tridentatus* se encuentra todavía en los riachuelos de la cuenca de Ventura, también en el Sur de California. Las observaciones de *E. tridentatus* en aguas oceánicas son muy escasas, y ninguna corresponde a la zona costera al Sur de la Bahía de Monterey, California. Se estima necesario llevar a cabo estudios sobre las razas de esta especie. La división de la especie en la subespecie septentrional y la meridional, no se considera aceptable. La designación adecuada de la especie y su autor es *Entosphenus tridentatus* (Gairdner en Richardson). Se encuentra justificado que el género *Entosphenus* se separe del género *Lampetra*; y así mismo se recomienda que se admitan como géneros junto con *Entosphenus* (que incluye un derivado no parásito todavía sin describir), a los subgéneros *Tetrapleurodon* y *Lethenteron*, que habían sido propuestos por Creaser y Hubbs como subgéneros de *Entosphenus*.

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